REMARKS

This application has been carefully reviewed in light of the Office Action dated August 19, 2005. Applicants have amended claims 1, 7 and 8. Reconsideration and favorable action in this case are respectfully requested.

The Examiner has rejected claims 7-12 under 35 U.S.C. §112, second paragraph. Applicants have amended claims 7 and 8 in accordance with the Examiner's concerns.

The Examiner has rejected claims 1 and 7 under 35 U.S.C. §102(b) as being unpatentable over U.S. Pat. No. 6,404,289 B1 to Su. Applicants have reviewed this reference in detail and do not believe that it discloses or makes obvious the invention as claimed.

The Examiner has rejected claims 1, 3-7, and 9-12 under 35 U.S.C. §102(e) as being unpatentable over U.S. Pat. No. 6,686,804 B1 to Adams et al. Applicants have reviewed this reference in detail and do not believe that it discloses or makes obvious the invention as claimed.

The Examiner has rejected claims 2 and 8 under 35 U.S.C. §103(a) as being unpatentable over Su. Applicants do not believe that this reference discloses or makes obvious the invention as claimed.

The Examiner has rejected claims 2 and 8 under 35 U.S.C. §103(a) as being unpatentable over Adams. Applicants do not believe that this reference discloses or makes obvious the invention as claimed.

With regard to the rejections under the Su reference, while the Su reference uses a capacitor bank to provide multiple frequency ranges in which the VCO may operate, it finds an appropriate setting of capacitor bank by serially stepping through different capacitor setting until lock can be achieved. Locking the tuning circuit requires operated

the VCO at *multiple* control voltages for each setting of the capacitor bank. Once lock is achieved, that setting is used. Specifically, Figures 6A-6C of Su illustrate the method for finding a curve that includes the desired frequency and has the highest control voltage. Initially, in the search phase, the VCO 500 in Su is set such that the all capacitors 510 are enabled in the circuit, i.e., all switches 520 are closed (col. 6, line 52-61). The synthesizer attempts to reach lock (step 612). If lock cannot be achieved (step 614), the capacitor register is decremented to reduce the capacitance (step 616), which causes the VCO 500 to operate at the next level lower curve (col. 7, lines 6-8). The process of checking for lock at a particular value of the capacitor register, and decrementing the capacitor register if lock is cannot be obtained at that value, is repeated until lock is obtained (col. 7, lines 13-14). Once a lock condition is found in step 614, the value of the control value used to obtain lock is checked (step 614). If the value is above or below upper or lower limits for the control voltage (step 630), a determination is made whether a lock condition can exist at another control voltage (step 632).

The method proposed by Su requires the frequency synthesizer attempt to lock at the desired frequency at every curve starting at the highest possible capacitive value. Accordingly, if lock can only be obtained at the lowest capacitive value, the search for a lock condition will result only after the synthesizer has attempted to lock at fifteen other capacitive combinations. A lock condition can only be evaluated on an active edge of the reference clock (fref in Su). At each active edge, a decision to increase or decrease the control voltage can be made (see Figure 3). Thus, it will take multiple fref clock cycles to determine whether lock can be obtained at any given switched capacitor setting.

The present invention works in a completely different manner in order to accurately obtain the proper frequency range in the fastest time. First, a search for an initial control word to control the switched capacitors (and hence the frequency range of the VCO) is performed at a *single* predetermined control voltage to the varactor (in the specification, the predetermined voltage is v_{cal}, set to the midpoint of the voltage range of

the varactor). Using a predetermined control voltage on the varactor to perform the search will not be sufficient to definitively identify a single control word that will set the VCO to the desired frequency range. However, on each clock cycle of the reference frequency, it can be determined whether f_{cal} (the frequency provided at v_{cal} for the current control word setting) is greater than or less than f_{wanted}. The outcome of this comparison can be used to control the search to quickly find a limited range of control words in which the correct control word must exist. For example, if one control word setting results in $f_{cal} > f_{wanted}$ and an adjacent control word shows $f_{cal} < f_{wanted}$, then one of those two control words will provide the proper frequency range for f_{wanted}. The search does not show which control word is correct in this case, it simply narrows the search to an initial control word within an accuracy of +/- 1 to the correct control word. It should be noted that a less accurate search could also be used. Once the initial control word is found, the limits of the frequency range can be found by using v_{min} and v_{max} to control the VCO in order to determine f_{max} and f_{min} for the range attributable to the initial control word. If $f_{wanted}>f_{max}$ or $f_{wanted}<f_{min}$, then the initial control word did not set the capacitor bank to the correct range and the initial control word is adjusted to an adjacent control word. The direction of change of the initial control word is easily determined by comparing f_{wanted} to the already-computed frequency range for the capacitor bank setting. With a searching accuracy of +/- 1, the initial control word will only need to be incremented or decremented once; this could be more with a search of less accuracy.

By making a determination at a single control voltage at each control word, the speed at which an initial control word is greatly reduced over a system such as Su, which attempts to lock at each control word. This aspect is described below in greater detail.

Using the example of Su which has sixteen possible control words (i.e. sixteen possible capacitor bank settings), a dichotomizing search can locate an initial control word in four reference clock cycles, and a ramping search (such as the one shown in Su) can locate an initial control word for the capacitor bank in no more than sixteen clock

cycles. Su, on the other hand, must adjust the control voltage to the VCO multiple times at each capacitor bank setting to determine whether lock can be achieved. Fore each new control voltage to the VCO, an entire reference clock cycle is used.

As described in the present application, once the initial control word is found, it can be tested to see if the control word produces a frequency range in the VCO which contains f_{wanted}. In the specification, this is performed by checking the boundary conditions, i.e., v_{max} and v_{min}. If the condition $f_{max} \geq f_{wanted} \geq f_{min}$ (where f_{max} is the highest frequency produced by the VCO and f_{min} is the lowest frequency produced by the VCO within the boundary conditions) is not met, then the control word must be increased or decreased by one (assuming the search is accurate to +/-1). It should be noted that the determinations of $f_{wanted} \geq f_{min}$ and $f_{min} \geq f_{wanted}$, as shown in the flow chart of Figure 7, can each be made in one reference clock cycle. Accordingly, in the example above, using a dichotomizing search, the proper control word will be determined within *at most* six reference clock cycles (four for the initial search, and up to two clock cycles for the determination whether the control word should remain at the initial control word or should increase or decrease). It should be noted that the above analysis does not take into consideration of settling time between changing control words, which would effect both the present invention and Su.

If a search with an accuracy of greater than +/-1 was used, the detailed search would take longer, since the initial control word may be separated from the correct control word by more than one.

Su does not teach a tuning circuit in which a search is performed using a single predetermined control voltage to the voltage controlled oscillator at various capacitive setting for the capacitor bank. Accordingly, Applicants request allowance of claims 1 and 7.

The Adams reference works in an entirely different manner. During a calibration phase, a replica charge pump 408 is enabled to generate minimum and maximum frequencies for each capacitor bank setting. The minimum and maximum frequencies are stored in a memory (correction table 420). The calibration phase is controlled by on-chip microcontroller (col. 5, lines 22-33). Once this is complete, the memory is used by a software controlled multicontroller to provide an appropriate value of N and a correct capacitor combination to satisfy a channel selection request (col. 5, lines 34-37). If a desired channel is available at two different capacitor bank settings, a minimum VCO control voltage is favored over a maximum VCO control voltage (col. 6, lines 27-34). An alternative embodiment in Adams stores the center frequency of each range, rather than the minimum and maximum. This is used in the same way to determine the correct capacitor configuration for a desired channel (col. 6, lines 44-59).

The Adams reference does not show a search by operating the VCO, nor does it show a search at single predetermined control value, nor does it show testing the initial control word to determine whether the initial control word should be used or whether it should be changed to an adjacent control word. As described above, Adams uses numerical values stored in a memory – it does not operate the VCO at a predetermined control voltage to find an initial control word. Further, Adams shows no selection of an initial control word followed by a test of the initial control word to determine whether it should be used to generate the clock signal.

The Adams reference requires a memory for a lookup table and, thus, a much more complex microcontroller than does the current invention, which only needs to compare f_{wanted} to f_{cal} at each potential control word until a initial control word is reached, then compare f_{wanted} to f_{min} and f_{max} to determine whether the initial control word should be changed to an adjacent control word.

The Commissioner is hereby authorized to charge any fees or credit any overpayment, including extension fees, to Deposit Account No. 20-0668 of Texas Instruments Incorporated.

Applicants have made a diligent effort to place the claims in condition for allowance. However, should there remain unresolved issues that require adverse action, it is respectfully requested that the Examiner telephone Alan W. Lintel, Applicants' Attorney at (972) 664-9595 so that such issues may be resolved as expeditiously as possible.

For these reasons, and in view of the above amendments, this application is now considered to be in condition for allowance and such action is earnestly solicited.

Respectfully Submitted,

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